A method of producing an abrasive cutting string provides for coating a plastomeric string with a solution of a solvent and the plastomeric material of the string, applying an abrasive and removing the solvent to thereby provide a cutting string with excellent abrasive bind and string coverage, that can be manufactured at high speeds.
METHOD OF MANUFACTURING ABRASIVE CUTTING STRING

FIELD OF THE INVENTION

[0001] This invention relates generally to an improved method of manufacturing abrasive cutting string commonly used as cutting string for cutting grass, weeds, brush and the like in combination with a rotary string trimmer.

BACKGROUND OF THE INVENTION

[0002] It is known to use extruded thermoplastic string such as of Nylon to cut grass, weeds, brush and the like in combination with a rotary string trimmer. Conventional thermoplastic strings, however, suffer from several disadvantages. For example, conventional strings have a substantially smooth exterior surface. More particularly, the exterior surface of conventional strings is devoid of any abrasive or aggregate materials which produce cutting surfaces. Instead, conventional strings rely on the rotational velocity and impacting force of the string to cut weeds, grass, brush and the like. This, however, is an inefficient way to cut grass, weeds and particularly vegetation that cannot be felled with impacting force of the cutting string. In addition, the smooth surface of conventional strings is devoid of any air voids which cool the string when it is rotated. As a result, conventional strings are known to melt and fuse in the head of a rotary string trimmer under normal or high temperature conditions. This results in costly and time-consuming repairs and requires replacement of conventional strings.

[0003] Further, the cross-sectional shape of conventional strings is usually circular. Consequently, conventional strings do not have any edges or raised profiles which improve cutting efficiency, and instead rely on the rotational velocity and impacting force of the string to cut grass, weeds, brush and the like. As noted above, this provides mostly impacting force and very little cutting action. Still further, as a result of the high rotational velocity and composition of conventional strings, the strings are susceptible to damage and breaking, and thus they have a limited lifespan. Finally, because conventional strings are inefficient (e.g., they rely upon the rotational velocity and force of impact of the string rather than any cutting surfaces on the string), the strings impart undue stress upon the rotary string trimmer with which they are used.

[0004] Some attempts have been made to improve upon conventional circular strings used to cut grass, weeds, brush and the like in combination with a rotary string trimmer. For example, cutting strings have been extruded in different cross-sectional shapes. More particularly, the circular cross-sectional shape of conventional strings has been modified to a cross-sectional shape having one or more edges or raised profiles such as an octagon. This modification of conventional strings, however, also suffers from many of the same disadvantages as conventional strings of circular cross-section. While the impacting force of a raised profile string may be delivered more efficiently in comparison to conventional strings having a circular cross-sectional shape, conventional strings having a cross-sectional shape with raised profiles or edges still have a generally smooth lengthwise exterior surface. Consequently, conventional strings having a cross-sectional shape with raised profiles or edges still rely substantially on the rotational velocity and impacting force of the string to cut, and the result is an inefficient way to cut grass, weeds, brush and the like.

[0005] Further, like conventional smooth surface circular strings, conventional smooth surface strings having a cross-sectional shape with raised profiles or edges are susceptible to melting and fusion in the head of the rotary string trimmer under normal or high temperature conditions. Again, this results in costly and time-consuming repairs and replacement of the string. Still further, like conventional strings having a smooth, circular cross-section, conventional strings having a smooth, cross-sectional shape with raised profiles or edges have a limited lifespan due to the composition of the string and the high rotational velocity of the string. Finally, because conventional strings having edges or raised profiles are inefficient for cutting purposes inasmuch as they rely upon the rotational velocity and force of impact of the string rather than cutting surfaces on the string, they impart undue stress on the rotary string trimmer with which they are used.

[0006] In an effort to overcome these shortcomings, some attempts have been made to mix abrasive particles with thermoplastic resins to produce string. These attempts generally are very taxing on string extrusion equipment, tend to leave most of the abrasive particles buried in the string, and have abrasive particles even in the core of the string. The result is a relatively weak or breakable string without substantial external abrasive particle cutting surfaces. Alternatively, gluing abrasives to the string also results in added cost and difficulties in manufacturing and string performance.

[0007] A variety of techniques have been proposed to create a cutting string with an uncompromised core, and with abrasives only on the outer surface and periphery of the string. For instance Legrand, U.S. Pat. No. 6,630,226 proposes using an adhesive to bond abrasives to the surface of a thermoplastic resin string. Ledford and Wood, U.S. Ser. No. 11/006,024, proposes two techniques. One is heating the string so that it is soft enough to have abrasives embedded in the outer surface. However, heating the cutting string sufficiently for this embedding process weakens the string to the extent that it has too little strength to be used for rotary cutting. The second proposal of Ledford and Wood is to soften the exterior surface of the cutting string by exposure to a solvent such as formic acid, and then to apply abrasives to the softened string surface. However, softening the string surface is a relatively slow process requiring some length of time for formic acid to produce Nylon sufficiently softened that it may have abrasive embedded. The embedding techniques of either drawing the acid softened string through sand or depositing sand on the softened string before taking the string up on rollers also provide relatively poor abrasive coverage on the string surface. The processing speeds that can be obtained appear unsuitable for commercial manufacturing, formic acid usage is high, and the amount of formic acid lost to evaporation is substantial.

[0008] Accordingly, it is an advantage of the invention described herein to provide an improved cutting string with an abrasive surface for cutting grass, weeds, brush and the like in combination with a rotary string trimmer.

[0009] It is yet another advantage of the invention to provide a simple and inexpensive method for making such an improved cutting string.

[0010] Additional advantages of the invention will become apparent from an examination of the drawings and the ensuing description.

SUMMARY OF THE INVENTION

[0011] The invention comprises a method of manufacturing cutting string for cutting grass, weeds, brush and the like
when used in combination with motorized rotary head cultivation implements. Some variants of the cutting string may be used as the cutting line for string or wire saws as well. The preferred cutting string is composed of a plastomer material and the manufacturing process fastens abrasives in plastomer materials coated on the periphery of the string. The abrasives are applied to the cutting string after the cutting string is coated with a solution of a solvent and the plastomer material comprising the string. This results in a viscous periphery of the string in which abrasive particles are embedded. Upon curing of the plastomer material as by evaporation of solvent, the abrasives are set about the periphery of the string in the plastomer material comprising the cutting string.

[0012] The method comprises the steps of forming a plastomer cutting string, which is usually extruded in the same way as conventional cutting strings in this field from a plastomer material, typically polyamide. The cutting string may have various profiles, the simplest shape being a circular cross-section but numerous alternative profiles have been proposed for cutting string such as disclosed in Skinner, Des. 376,739, Des. 379,052, Des. 379,418 and Des. 379,419; Fogle, U.S. Pat. No. 6,434,837 and Morabit, U.S. Pat. No. 5,996,233 with various jagged profiles. In a preferred method the cutting string is then passed through a solution of about 10 to 20 percent weight by volume of a solution of plastomer string material. This results in the string having a viscous periphery of plastomer material to which an abrasive coating is applied. The abrasive particles are typically inorganic particles such as silica, glass, fine sand, emery, marble, and coarse garnet. A variety of metallic particles such as carburrendum, zinc, iron, and aluminum, especially in the form of powdered oxides of appropriate particle size may also be suitable abrasive coatings. In addition, particles of synthetic materials such as rigid plastics and combinations of two or more of the previously mentioned substances may also be advantageous.

[0013] The addition of abrasive particles enhances the cutting efficacy of the cutting strings by providing not only the impacting force of the string but also providing a sawing effect. The combination of the abrasive sawing effect in combination with the impact of the cutting line due to the rotational velocity significantly improves the cutting capability of the line, especially in connection with the heavier vegetation that cannot be severed by impacting force alone. As an added benefit, the nature of the abrasive particles may also improve the thermal characteristics of the cutting line and reduce any tendency of the cutting line to stick due to approaching melting point of the plastomer material. In addition, with the appropriate abrasive coatings it becomes possible to rely upon the cutting or sawing effect of the abrasives to a much greater degree than the impacting effect of the rotational velocity imparted by the rotating head of the implement. In this case, the rotational speed of the head may be significantly reduced to perhaps several hundred rpm rather than several thousand rpm facilitating the use of less powerful motors and reducing the noise generated by the rotary head cultivation implement employed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] The presently preferred embodiments of the invention are illustrated in the accompanying drawings in order to facilitate an understanding of the invention, in which like reference numerals represent like parts throughout, and in which:

[0015] FIG. 1A is a partial cross-sectional view of a preferred embodiment of a cutting string made in accordance with the present invention.

[0016] FIG. 1B is an enlarged view of the circled portion of the cutting string illustrated in FIG. 1A.

[0017] FIG. 2 is a schematic diagram of a preferred embodiment of the method for making cutting string in accordance with the invention.

DESCRIPTION OF THE INVENTION

[0018] Referring now to the drawings, a cutting string 10 and a preferred method for making the cutting string of the invention are illustrated by FIGS. 1 through 2. As shown in FIG. 1A, a preferred cutting string is designated generally by reference numeral 10. The cutting string 10 is composed of a plastomer material 11 such as Nylon 6 or Nylon 66 that is extruded to have a substantially circular cross-sectional shape. It is contemplated within the scope of the invention, however, that cutting string 10 may be composed of any suitable material that may be formed into a string-like configuration. Further, it is contemplated within the scope of the invention that cutting string 10 may be formed to have any suitable cross-sectional shape such as oval, crescent, semicircular, triangular, square, rectangular, pentagonal, hexagonal, octagonal or any other polygonal shape. It is further contemplated within the scope of the invention that cutting string 10 may be produced by a process other than extrusion such as molding, drawing or any other suitable process for producing string. It is still further contemplated that the cutting string of the invention may be configured as blades adapted to be used on a motorized rotary head cultivation implement.

[0019] Still referring to FIG. 1A, cutting string 10 includes a plurality of abrasives 12. Abrasives 12 are preferably composed of very fine foundry sand or some other similar material such as very fine aggregates, metal oxide powders, and the like. Abrasives 12 are attached to cutting string 10 by being partially embedded on the exterior surface of cutting string 10, so that feet 13 of abrasives 12 are surrounded by the plastomer material 11 of the cutting string 10. Also in the preferred embodiment, abrasives 12 cover the substantially entire exterior surface of cutting string 10. Abrasives 12 are adapted to produce a non-smooth surface on the exterior of the cutting string. As shown in FIG. 1B, the non-smooth surface produced by abrasives 12 produces a plurality of cutting surfaces 14 protruding from the plastomer material 11 of the cutting string 10. The plurality of cutting surfaces 14 improves the cutting efficiency of the cutting string 10 as compared to conventional smooth surface strings.

[0020] As a result of cutting surfaces 14, cutting string 10 need not be rotated at the same high velocity as conventional smooth surface strings in order to cut the same grass, weeds, brush and the like. Further, cutting string 10 having cutting surfaces 14 reduces the amount of stress imparted upon the rotary string trimmer with which it is used because of its improved cutting efficiency. Still further, the abrasives 12 on cutting string 10 permit the string to cut through larger, thicker and denser vegetation than conventional smooth surface strings.

[0021] Abrasives 12 on the surface of string 10 provide an additional advantage. As shown in FIG. 1B, the abrasives
produce a non-smooth surface which results in a plurality of air voids. Air voids cool cutting string as it rotates, thereby reducing the temperature of the cutting string and inhibiting melting and fusion of the plastomeric material of cutting string.

[0022] Referring now to FIG. 2, a presently preferred method of making cutting string is illustrated. More particularly, as shown in FIG. 2, the method of making cutting string includes the steps of feeding Nylon pellets into hopper 22, which are melted and extruded in the form of cutting string 10 by extruder 24. As discussed above, Nylon 6 or Nylon 66 any other suitable plastomeric material may be used to produce the cutting string. Further, as discussed above, cutting string 10 may be extruded by extruder 24 or formed by any other suitable method or device for producing a cutting string. A typical circular cross-sectional string core would have a diameter between about 0.1 and 0.05 inches, and most preferably between 0.06 and 0.07 inches for use in a customary string trimmer application.

[0023] Still referring to FIG. 2, the illustrated method also includes the step of coating the cutting string with a solution of the string core material for instance, a Nylon 6 string core will be passed through a bath 26 made in a ratio of about 15 grams of Nylon 6 per 100 milliliters of formic acid. A typical bath would be approximately 10 to 20 percent, and preferably about 13 to 16 percent, weight by volume of Nylon 6 or other plastomeric material comprising the cutting string and the balance of one or more solvents. Lower concentrations of the dissolved plastomeric material are not desirable because it may result in an insufficiently viscous material on the periphery of the cutting string to bond with the abrasive particles, at least without slowing the process down substantially as required for the solvents to begin to dissolve the string itself to generate the material needed for adhesion. Higher concentrations of the plastomeric material would be desirable, however, depending upon the method used, it can be difficult to apply the coating of dissolved polymer evenly and to prevent the buildup of a greater thickness of additional plastomeric material than is desired. Preferably bath 26 is in communication with a fume hood and condenser in order to capture solvent vapors from the bath. The cutting string after passing through the solution of bath 26 has the excess solution brushed off to achieve relatively uniform coating over the cutting string. Brushes would typically be made of another material such as Nylon 12 that is not dissolved by the solvent, which typically in the case of Nylon 6 is formic acid. The wet, solution-coated cutting string proceeds directly through fine abrasives such as sand, coarse garnet, aluminum oxide or other metal powders as discussed previously. The string may be immersed in an abrasive or simply have an abrasive applied to it at this abrasive coating station. The abrasive covered string then proceeds to an evaporation station where hot air may be circulated over and around the string to remove solvents, such as formic acid, which are captured by a vent hood and to condenser so that formic acid may be precipitated in some cases reused. The dried cutting string is preferably finished to a uniform size by as passing through sizing die 44 and then wound on a take up reel. It is contemplated within the scope of the invention that the cutting string may be stored in any suitable manner using any suitable storage device.

[0024] The selection of Nylon 6 and Nylon 66 as plastomeric materials utilized for the cutting string is desirable because of their solubility in formic acid. As a solvent, formic acid is desirable because the temperature required to evaporate the residual formic acid in heating chamber is typically only between 100 and 150 degrees centigrade. The solution of formic acid and Nylon 6 or Nylon 66 also has excellent tenacity so that the abrasive materials stick easily in the viscous coating on the cutting string.

[0025] The abrasive densities achieved on the cutting strings manufactured in this fashion are much improved over the techniques of Ledford and Wood and the strength of the cutting string is not diminished. Continuous processing speeds between 200 and 2,000 feet per minute may be achieved on properly engineered manufacturing equipment. The preferred particle size for abrasives is between about 30 mesh and 70 mesh. When particle sizes of the abrasive material become larger than 30 mesh, it is more difficult for the particles to adhere to the viscous coating on the cutting string. It is also desirable that the abrasive particles have angular surfaces as round glass beads, while initially adhering, and simply fall off when the cutting string is rubbed. The majority of suitably angular particles may be securely fixed to the string, preferably with the majority of the abrasive particles having a binding strength to the string in excess of half of the tear strength of the beginning string core.

[0026] A representative coating density on a 0.06334 in diameter string core covered with 30 mesh sand is about 0.4 grams of sand per square inch of string core surface after the final uniform sizing of the abrasive string. The coating density for a 30-40 mesh ground garnet (abrasive) is 0.45-0.45 grams per square inch after final sizing. The resulting abrasive cutting string will typically have a diameter of about 0.095 and 0.125 inches, and most preferably between 0.10 and 0.105 inches. It is desirable to achieve a coating of abrasive particles that cover at least 95, 96, 97, or 98 percent of the surface area of the string core, and preferably at least 99 percent of the surface area. The resulting abrasive string will also have good tensile strength preferably in excess of 30 pounds, 60 pounds, 90 pounds, 120 pounds, 150 pounds, 180 pounds and 210 pounds.

[0027] In operation, several advantages of the apparatus and method of the invention are achieved. The abrasives of the cutting strings produce a plurality of cutting surfaces and air voids about the exterior surface of the string. The irregular exterior surface of these cutting strings results in several advantages. For example, the plurality of cutting surfaces produced by the abrasive particles on the cutting string improves the cutting efficiency of the string. More particularly, the cutting surfaces of the cutting string contribute to the ability of the string to cut grass, weeds, brush, and the like. The abrasive cutting string of the invention relies on the cutting surfaces of the embedded abrasives as well as the rotational velocity and impacting force of the cutting string to cut vegetation. The result of the plurality of cutting surfaces on the periphery of the cutting string is that the cutting efficiency of the abrasive cutting string is increased, the rotational velocity of the abrasive cutting string need not be as high as the rotational velocity of a conventional smooth surface cutting string in order to cut the same grass, weeds or the like, the amount of stress imparted upon the rotary string trimmer in which the cutting string is used is decreased, the cutting string cuts grass, weeds and the like up to 40% faster than conventional smooth surface strings, and the abrasive cutting string
is capable of cutting grass, weeds and the like that are up to ten times larger than the vegetation that conventional smooth surface cutting strings are capable of cutting.

[0028] The plurality of air voids produced by the abrasives of the abrasive cutting string also produce several advantages. For example, the air voids of the preferred cutting string have a cooling effect upon the string as it is rotated such as by a rotary string trimmer. The cooling effect of the air voids reduces the likelihood that the cutting string will melt or fuse under high temperature conditions. Consequently, repairs and replacements of the cutting string are reduced as compared to conventional smooth surface cutting strings. As a result, the cutting string is less expensive and less time-consuming to repair and requires less frequent replacement.

[0029] The methods of making the abrasive cutting string also achieve several advantages. For example, the described method provides a simple and inexpensive way to manufacture the preferred cutting string.

[0030] All publications, patents and patent documents are incorporated by reference herein as though individually incorporated by reference. Although preferred embodiments of the present invention have been disclosed in detail herein, it will be understood that various substitutions and modifications may be made to the disclosed embodiment described herein without departing from the scope and spirit of the present invention as recited in the appended claims.

I claim:

1. A method of manufacturing an abrasive cutting string comprising the steps of:
   (a) selecting a string made of a plastomeric material;
   (b) coating the string with a solution comprising a solvent and the plastomeric material;
   (c) applying an abrasive to the solution coated string; and
   (d) removing the solvent from the abrasive coated string;

2. The method of claim 1 further comprising the step of winding the abrasive cutting string upon a reel.

3. The method of claim 1 wherein the plastomeric material is polyamide.

4. The method of claim 3 wherein the polyamide is selected from Nylon 6, Nylon 66 and mixtures thereof.

5. The method of claim 4 wherein the solvent is formic acid.

6. The method of claim 4 wherein the polyamide is in the solution at a concentration of between 10 percent and 20 percent weight by volume.

7. The method of claim 1 wherein after solution is applied to the string the excess solution is brushed off the surface of the string.

8. The method of claim 1 wherein solvent vapors are captured when the solvent is removed and the solvent is recovered by condensation.

9. The method of claim 1 wherein the abrasive is selected from the group of silica, glass, fine sand, emery, marble, coarse garnet, metal particles, plastic particles, and mixtures thereof.

10. The method of claim 1 wherein the abrasive particles have a mesh size in the range from about 30 mesh to about 70 mesh.

11. The method of claim 1 wherein the string is coated with abrasive particles at a speed of at least 200 feet per minute.

12. The method of claim 1 wherein the abrasive particles cover at least 99 percent of surface area of the string.

13. The method of claim 1 wherein at least 50 percent of the abrasive particles have a bind strength in excess of half of the tear strength of the string of plastomeric material.

14. The method of claim 1 wherein the diameter of the uncoated string of plastomeric material is greater than 60 percent of the diameter of the abrasive coated string.

15. The method of claim 1 wherein the abrasive is applied to the solution coated string at a rate of about four grams per square inch of surface on the uncoated string of plastomeric material.

16. The method of claim 1 wherein the abrasive particles cover at least 95 percent of the surface areas of the string and at least half of the abrasive particles have a bind strength greater than half the tear strength of the string’s plastomeric material.

17. A method of manufacturing an abrasive cutting string comprising the steps of:
   (a) selecting a string made of a Nylon soluble in formic acid;
   (b) coating the Nylon string with a solution of 10 to 20 percent by weight of Nylon dissolved in formic acid;
   (c) applying abrasive particles of between about 30 mesh and 70 mesh size to the solution coated Nylon string;
   (d) heating the abrasive coated string to a temperature of between about 100 and 150 degrees centigrade to substantially remove the formic acid;
   (e) recovering formic acid by condensation;
   (f) uniformly sizing the abrasive string; and
   (g) winding the abrasive coated string upon a reel.

18. The method of claim 17 where the abrasive particles cover over 95 percent of the surface of the string made of a Nylon.

19. The method of claim 17 wherein the diameter of the string made of Nylon is greater than 60 percent of the diameter of the abrasive coated string.

20. The method of claim 17 wherein the abrasive is applied to the solution coated Nylon string at a rate of about four grams per square inch of surface of the string made of Nylon.

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